following: whether rickets is due to lack of Fat Soluble A, whether there is an antiscorbutic vitamine (Water Soluble C), and in what sense pellagra may be rated as a deficiency disease. All the material is handled in a cautious and modest way with the result that no encouragement is given to faddists of any kind.

PERCY G. STILES

EXPERIMENTS ON THE RECORDING AND REPRODUCTION OF CARDIAC AND RESPIRATORY SOUNDS

WE have recently conducted experiments at the Bureau of Standards in which permanent records of cardiac and respiratory sounds have been made and reproduced by the use of a telegraphone. The records have also been made audible throughout the room with the aid of audion amplifiers and a loud-speaking telephone.

A carbon telephone transmitter of ordinary type with a rubber adapter substituted for the mouthpiece was used for the stethoscope. The currents from the telephone transmitter were amplified by means of a five-stage audion amplifier which was connected to the recording element of a steel wire telegraphone. The magnetic records of the cardiac and respiratory sounds thus obtained were made audible by connecting telephone receivers to the telegraphone in the usual manner. The telegraphone currents were also amplified by means of a three-stage audion amplifier which was connected to a loud speaking telephone. In this way the sounds were made audible throughout the room.

This method of obtaining permanent records of cardiac and respiratory sounds and of reproducing them offers interesting possibilities in the study of normal and pathological conditions of the heart and lungs and their demonstration to an audience for purpose of instruction.

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SPECIAL ARTICLES

THE SEPARATION OF THE ELEMENTS CHLORINE AND MERCURY INTO ISOTOPES

IN SCIENCE of March, 1920, Harkins and Broeker reported that they had obtained a separation of chlorine into isotopes by diffusing hydrogen choride gas. The separation at that time amounted to an increase of atomic weight equal to 0.055 unit, or a change of density amounting to 1,550 parts per million. This separation has been definitely confirmed by Dr. Anson Hayes and the writer, who have secured an increase of 0.04 unit of atomic weight in a larger quantity of material. Elaborate purifications have been resorted to, and definite evidence has been secured to show that the increase in density found is actual, and not due to impurities. The details of this work were supposed to have been printed in the August number of the *Journal* of the American Chemical Society. However, since the date of publication of this number is doubtful on account of the printers' strike, it seemed advisable to answer here the considerable number of inquiries as to whether we have secured definite evidence of the separation.

About six months after our notice of the separation of chlorine into isotopes had been published, Bronsted and von Hevesy published a notice in *Nature* indicating that they had separated mercury into isotopes. However, since the extent of the density change reported by them was only about *one thirtieth* of that previously obtained by us in the case of chlorine, it seemed to us that the evidence for this separation of mercury was inconclusive, since a change of 50 parts per million in density might be due to minute amounts of impurities. In order to see if they could confirm these results, Dr. R. S. Mulliken and the writer have vaporized mercury at low pressures. The mercury was carefully purified by five fractional distillations in air at low pressures, and one in a high vacuum, after initial purifications with nitric acid. The increase in density obtained amounts to 69 parts, and the decrease to 64 parts or a total

change of density of 133 parts per million, or 0.027 unit of atomic weight.

The evidence that a separation has actually been obtained rests in the quantitative agreement between our results and those of Bronsted and von Hevesy, with respect to the rate of separation (efficiency of process). If we consider the efficiency of our more ideal apparatus as 100 per cent., that of the other investigators is 75 per cent. while that of our less ideal apparatus used in the greater part of the work in order to save the expense of carbon dioxide as a cooling agent, was 93 per cent. when the vaporization was slow, and as low as 80 per cent. for a rapid vaporization. We have obtained evidence that there is a slight separation of isotopes produced when mercury is *distilled* slowly at a sufficiently low pressure.

The rate of separation of two isotopes varies as the *square* of the difference of their atomic (or molecular) weights, and the product of their mol fractions, as the logarithm of the cut, and inversely as the atomic (or molecular) weight.

A diffusion coefficient has been calculated to represent the relative separation of isotopes attained in terms of the atomic weight change, when a definite cut is made. The values are 0.00843 for neon, 0.00868 for magnesium, 0.00450 for lithium, 0.00758 for nickel, while the experimentally determined coefficient for mercury is 0.00570. For chlorine the coefficient is 0.00950 for hydrogen chloride, 0.00690 for methyl chloride, 0.00494 for chlorine, 0.00413 for methylene chloride, 0.00295 for chloroform, and 0.00229 for carbon tetrachloride.

It is of interest to note that there are 9 isotopic forms of $MgCl_2$ (or more if there is a chlorine of atomic weight equal to 39), 7 of C_6Cl_6, and if mercury consists of 6 isotopes, there are 63 isotopic forms of Hg_2Cl_2. In addition to this most of the isotopic forms of C_6Cl_6 consist of a number of space isomers.

William D. Harkins

University of Chicago,
August 30, 1921

An Artificial Nerve

Physiologists are keenly interested in all attempts to discover an explanation or an analogy for the passage of the nerve stimulus. Most enlightening suggestions have recently been presented by Lillie[1] in his studies of passivity phenomena in pure iron wires. It seems that the transmission of the momentary wave of activity which occurs in a passive iron wire on activation in 70% nitric acid is closely analogous both chemically and electrically to the passage of the nerve impulse.

The general similarity of the two phenomena was apparently first noticed by Wilhelm Ostwald and subsequently elaborated by his student Heathcote.[2] In a paper published in 1907 under the caption "Transmission along a nerve" (p. 909) Heathcote writes as follows:

> In 1900, then, Prof. Ostwald called our attention to the possibility of nerve transmission being a process akin to the transmission of activity. . . . It is to be expected . . . that transmission of activity would be slower immediately after the first transmission owing to products of reaction around the iron. This has been confirmed by direct experiments in the case of iron in nitric acid. An effect of this kind in a nerve would explain the nature of "fatigue" so far as it concerns nerves.

After discussing the small amount of energy consumption in both transmissions Heathcote summarizes his conclusions as follows:

> There is nothing in the structure of nerve which renders it impossible to regard transmission as occurring in a way which is analogous to the transmission of activity along passive iron. . . . It appears possible too that the network in protoplasm may be a layer capable of transmitting changes in a similar way and which manifest themselves as an essential part of the mechanism of irritability.

It is not surprising that Heathcote's paper should have escaped the attention of physiolo-

[1] Lillie, R. S., '18, Science, 43, 51; '20, *J. General Physiol.*, 3, 107.

[2] Heathcote, H. L., '07, *J. Soc. Chem. Industries*, 26, 899.